Chapter 7

Tides and Currents

Introduction

The ability to determine the height of a tide or velocity of a current is necessary for the safe navigation of any vessel. There are many methods of determining this data. The Quartermaster uses the Tide Tables and Tidal Current Tables that you were introduced to in Chapter 4. In this chapter, you will learn the actual mechanics of determining tide heights and current velocities.

Objectives

The material in this chapter will enable the student to:

- Define the following terms associated with the rising and falling tide phenomena:
  a. High tide or high water; low tide or low water
  b. Range of tide and the duration of rise and fall
  c. Stand
- Define the terms *spring tide* and *neap tide.*
- Match the three types of tides listed below with their characteristics:
  a. Semidiurnal
  b. Diurnal
  c. Mixed
- Match the following terms associated with tidal reference planes with their definitions:
  a Charted depth
  b. Mean high water (MHW)
  c. Mean low water (MLW)
  d. Mean lower low water (MLLW)
  e. Mean range of tide
- Extract the following information from tables 1 through 3 of the Tide Tables:
  a. Reference station
  b. Subordinate station time and height differences
  c. Correction factor for height at any time

Objectives, Continued

- Calculate the height of tide at any time for any station listed in the Tide Tables.
- Plot tidal information on a tide graph.
- Match the following terms with their meanings:
  a. Tidal and nontidal currents
  b. Flood and ebb
  c. Slack water
  d. Duration of flood and ebb
  e. Set and speed of current
  f. Rotary current
- Identify the general features of tidal currents.
- Calculate the times of minimum and maximum current and slack water at a given location, as well as the average direction of the current.
- Calculate the speed of the current at any time for any location.

Introduction to Tides

Background Information

Whenever your ship enters or leaves port, one of your most important tasks will be to calculate how much water will be available along your route of transit. The importance of accurate tide calculations cannot be overemphasized. If your ship attempts to pass beneath a bridge without adequate vertical clearance, you could lose the ship's mast. If you pass over a shoal with an insufficient depth of water, your ship will probably go aground, losing sonar dome, rudder, and propellers. All navigational charts reference the depth soundings in mean low water.

Definition

Tide is the vertical rise and fall of the ocean level caused by the gravitational forces between Earth and the Moon, and Earth and the Sun. Generally speaking, these interacting forces between the planets cause the tides to rise and fall twice daily, this is known as a tidal day. The period of one high and one low is referred to as a tidal cycle.

Terms Associated with Tides

Use the following table to learn the meanings of terms that are associated with tides.

Term	Definition
High tide or high water (HW)	The maximum height of the water resulting from the rising tide.
Low tide or low water (LW)	The minimum height of the water resulting from the outgoing tide.
Duration of rise and fall	The period of time measured in hours and minutes that it takes the tide to go from low water to high water.
Range of tide	The distance between HW and LW.
Stand	A brief period where no rise or fall occurs; this occurs when the tide reaches its maximum or minimum level.
Mean high water (MHW)	The average height of all high-tide water levels, measured over a 19-year period.
Mean low water (MLW)	The average height of all low-tide levels, observed over a 19-year period.
Mean lower low water (MLW)	The average of the lower of the low water levels, observed over a period of 19-years. This is the reference plane currently used on almost all charts covering U.S. waters as the basis of measurement of charted depths and height of tide.

Effect of the Sun and Moon on Tides

Spring and Neap Tides

As previously mentioned, tides that occur on Earth result from both solar and lunar influences. When these two bodies are in line with Earth, as shown in figure 7-1, their combined effect causes high tides to be higher than average and low tides to be lower than average. These types of tides are referred to as spring tides (and has nothing to do with the season of the year).

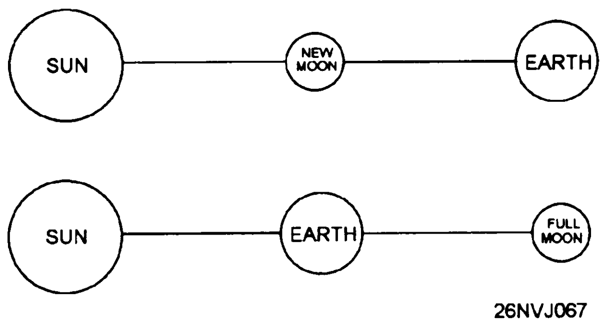

Figure 7-1. Spring tides occur when influences of the Sun and the Moon act together.

When the direction of the Sun and the Moon are 90° apart, as when the Moon is in the first and last quarter, the gravitational effect of the Sun counteracts that of the Moon enough that both high and low tides are lower than normal. These types of tides are referred to as neap tides.

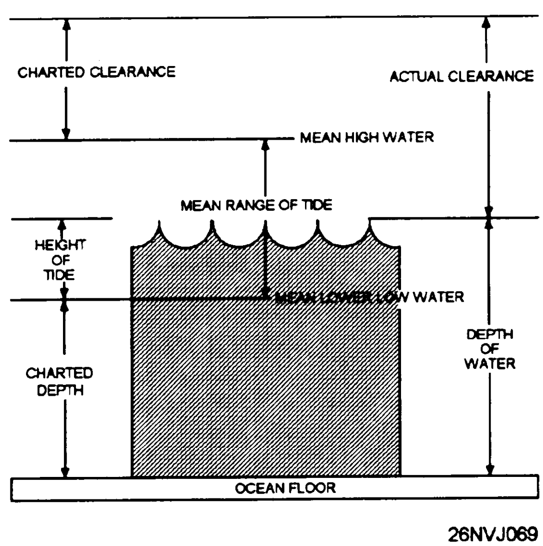

Figure 7-2. Relationship of terms used when measuring heights and depths.

Types of Tides and Reference Planes

Semidiurnal, Diurnal, and Mixed Tides

According to the characteristics of the tidal pattern occurring at a particular place, tides are classified as semidiurnal, diurnal, or mixed.

In **semidiurnal tides,** there are two high and two low tides each tidal day, and they occur at fairly regular intervals. Usually, there are only relatively small variations in the height of any two successive high or low waters. Tides on the Atlantic coast of the United States are representative of this pattern.

In **diurnal tides,** there is only one high and one low tide each tidal day. The water levels on succeeding days usually do not vary a great deal. In the United States, diurnal tides occur along the northern shore of the Gulf of Mexico.

In **mixed tides,** the tidal pattern is characterized by wide variations in heights of successive high and low waters. There are usually two high and two low waters each day, but occasionally the tide may become diurnal. In the United States, mixed tides occur along the Pacific Coast, Alaska, and Hawaii. If information for water depths, heights, elevations of topographical features, aids to navigation, bridge clearances, and so forth are to be meaningful when printed on nautical charts, standard reference planes for their measurements must be used. For this reason, standard reference planes for these measurements have been established.

Generally speaking, heights and elevations are given on a chart in reference to a standard high-water plane, while heights of tide and charted depths of water are given with respect to a standard low-water plane (see fig. 7-2). The **charted depth** is simply the vertical distance from the low-water reference plane to the ocean bottom; it’s the depth figure you see printed on nautical charts. The charted height is the vertical distance above the water measured from the high-water reference plane.

The **mean range of tide** is the vertical distance between the high water and low-water reference planes used, and represents the **average range of tide** at a given location. You should remember that the water level will sometimes be below the reference plane. Put another way, sometimes the actual **depth of water** can be less than the **charted depth.** You will recognize this situation because there will be a minus sign (-) placed before the height of tide shown in the Tide Tables. In this case, you subtract the value of the **height of tide** from the **charted depth** to find the **actual depth of water.**

Tide Tables

Layout

Tide Tables are published annually by the National Oceanic and Atmospheric Administration. They are published in four volumes: Europe and West Coast of Africa (including the Mediterranean Sea); East Coast of North and South America (including Greenland); West Coast of North and South America (including the Hawaiian Islands); Central and Western Pacific Ocean and Indian Ocean.

The Tide Tables contain seven tables; each are briefly explained below:

Table 1 contains the predicted times and heights of high and low waters for each day of the year at a number of places called reference stations. All times stated in this table are for standard time. When using daylight savings time, you must remember to add 1 hour.

Table 2 contains tidal difference information for heights and times at a number of places called subordinate stations. This information is listed in geographical order; each subordinate station is given a number, its location is described, and its position is given to the nearest minute. The data given for the subordinate station are applied to the predictions at a specified reference station to obtain the tidal information for the subordinate station. You'll see how this works in the example problems that follow.

Table 3 contains information used for finding the approximate height of the tide at any time between high and low water. This table also contains instructions for plotting tide information using a graphical method. The graphical method is handy for those occasions when the height of tide is required for a number of times on a given day.

Table 4 is a sunrise-sunset table listing LMT of the Sun's upper limb for every 5th day of the year.

Table 5 provides an adjustment to convert the LMT found in table 4 to zone or standard time.

Table 6 gives the zone time of moonrise and moonset for each day of the year at certain places.

Table 7 is a conversion of feet to meters table.

How to Determine the Height of Tide

Procedure

Finding the **height of the tide** is relatively simple. In the following example, we will calculate the height of tide at the George Washington Bridge on the Hudson River, NY. The time desired is 1100 standard time, 8 September 1993. To make our job easier, we will use OPNAV strip form *3530/40 HT OF TIDE.*

OPNAV 3530/40 (4-73) HT OF TIDE	Step	Action	Completed Strip Form
Date	1.	Enter the desired date.	08 SEPT
Location	2.	Enter the location. Find George Washington Bridge in the alphabetical index in the back of the Tide Tables. The subordinate station number is found to be #1561 in table 2.	George Washington Bridge
Time	3.	Enter the desired time.	1100
Ref Station	4.	The reference station is found by first finding our subordinate station (George Washington Bridge) #1561 in table 2, and then looking in the center of the DIFFERENCE column and following it upward (as shown in fig. 7-4) to the line entitled “on New York p. 56." Figure 7-3 is an excerpt from table 2. The data for steps 5, 6, 7, and 8 are found by inspecting the times and heights differences for 8 Sep for the George Washington Bridge.	New York

How to Determine the Height of Tide, Continued

OPNAV 3530/40 (4-73) HT OF TIDE	Step	Action	Completed Strip Form
HW Time Diff	5.	Under the DIFFERENCES column find the value for high-water time.	+0 50
LW Time Diff	6.	Under the DIFFERENCES column find the value for low-water time.	+0 46
HW Ht Diff	7.	Under the DIFFERENCES column find the value for high-water height.	*0.84
LW Ht Diff	8.	Under the DIFFERENCES column find the value for low-water height.	*0.85

TABLE 2 – TIDAL DIFFERENCES AND OTHER CONSTANTS

No.	PLACE	POSITION		DIFFERENCES				RANGES		Mean Tide Level
		Latitude	Longitude	Time		Height		Mean	Spring	
				High Water	Low Water	High Water	Low Water			
		North	West	h m	h m	ft	ft	ft	ft	ft
	NEW YORK and NEW JERSEY New York Harbor									
				on New York, p.56						
1535	Bay Ridge	40° 38'	74° 02'	−0 20	−0 21	*1.01	*1.00	4.6	5.5	2.5
1537	St. George, Staten Island	40° 39'	74° 04'	−0 17	−0 15	*0.99	*0.99	4.5	5.4	2.4
1539	Bayonne, N.J.	40° 41'	74° 06'	−0 15	−0 05	*0.99	*0.99	4.5	5.4	2.4
1541	Gowanus Bay	40° 40'	74° 01'	−0 18	−0 12	*1.03	*0.95	4.7	5.7	2.6
1543	Governors Island	40° 42'	74° 01'	−0 07	−0 03	*0.96	*0.95	4.4	5.3	2.4
1545	NEW YORK (The Battery)	40° 42'	74° 01'	*Daily Predictions*				4.6	5.5	2.5
	Hudson River <8>									
1547	Jersey City, Con Rail RR. Ferry, N.J.	40° 43'	74° 02'	+0 11	+0 10	*0.96	*0.96	4.4	5.3	2.4
1549	New York, Desbrosses Street	40° 43'	74° 01'	+0 14	+0 13	*0.96	*0.95	4.4	5.3	2.4
1551	New York, Chelsea Docks	40° 45'	74° 01'	+0 21	+0 19	*0.94	*0.95	4.3	5.2	2.3
1553	Hoboken, Castle Point, N.J.	40° 45'	74° 01'	+0 21	+0 19	*0.94	*0.94	4.3	5.2	2.3
1555	Weehawken, Days Point, N.J.	40° 46'	74° 01'	+0 28	+0 26	*0.92	*0.92	4.2	5.0	2.3
1557	New York, Union Stock Yards	40° 47'	74° 00'	+0 31	+0 29	*0.92	*0.92	4.2	5.0	2.3
1559	New York, 130th Street	40° 49'	73° 56'	+0 41	+0 38	*0.88	*0.88	4.0	4.8	2.2
1561	George Washington Bridge	40° 51'	73° 57'	+0 50	+0 46	*0.84	*0.85	3.9	4.6	2.1
1563	Spuyten Duyvil, west of RR. bridge	40° 53'	73° 56'	+1 02	+0 58	*0.83	*0.83	3.8	4.5	2.1
1565	Riverdale	40° 54'	73° 55'	+0 48	+0 49	*0.85	*0.91	3.9	4.7	2.1
1567	Yonkers	40° 58'	73° 54'	+1 13	+1 13	*0.81	*0.82	3.7	4.4	2.0
1569	Dobbs Ferry	41° 01'	73° 53'	+1 33	+1 43	*0.74	*0.73	3.4	4.0	1.9
1571	Tarrytown	41° 05'	73° 52'	+1 49	+1 57	*0.70	*0.70	3.2	3.7	1.8
1573	Ossining	41° 10'	73° 52'	+1 57	+2 17	*0.68	*0.68	3.1	3.6	1.8
1575	Haverstraw	41° 12'	73° 58'	+2 03	+2 28	*0.64	*0.64	2.9	3.4	1.5
1577	Peekskill	41° 17'	73° 56'	+2 28	+3 03	*0.64	*0.64	2.9	3.4	1.8
1579	West Point	41° 24'	73° 57'	+3 20	+3 40	*0.59	*0.59	2.7	3.1	1.7
1581	Newburgh	41° 30'	74° 00'	+3 46	+4 03	*0.62	*0.64	2.8	3.2	1.5
1583	New Hamburg	41° 35'	73° 57'	+4 04	+4 28	*0.64	*0.64	2.9	3.3	1.6
1585	Poughkeepsie	41° 42'	73° 57'	+4 34	+4 46	*0.68	*0.68	3.1	3.5	1.7
1587	Hyde Park	41° 47'	73° 57'	+5 00	+5 12	*0.70	*0.68	3.2	3.6	1.8
1589	Kingston Point	41° 56'	73° 58'	+5 20	+5 34	*0.81	*0.82	3.7	4.2	2.0
1591	Tivoli	42° 04'	73° 56'	+5 50	+6 04	*0.86	*0.86	3.9	4.4	1.9
1593	Catskill	42° 13'	73° 51'	+6 41	+6 58	*0.84	*0.91	4.1	4.8	1.9
1595	Hudson	42° 15'	73° 48'	+6 58	+7 12	*0.88	*0.86	4.0	4.4	2.2

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Figure 7-3. Excerpt from table 2 of the Tide Tables.

OPNAV 3530/40 (4-73) HT OF TIDE	Step	Action	Completed Strip Form
Ref Sta HW/LW Time	9.	From the reference station (see fig. 7-4), enter the values for the HW and LW that 0700 falls between. See figure 7-3.	HW 1241/ LW 0536
HW/LW Time Diff	10.	Write in the values from steps 5 and 6.	HW +50 / LW + 46
Sub Sta HW/LW Time	11.	Apply time difference corrections.	1241 + 50 = 1331 HW Time; 0536 + 46 = 0622 LW Time
Ref Sta HW/LW Ht	12.	From the reference station (table 1) enter the values for the HW and LW heights that correspond with step 9.	HW 4.7 / LW 1.2
HW/LW Ht Diff	13.	Write in the values from steps 7 and 8.	HW *0.84 / LW *0.85
Sub Sta HW/LW Ht	14.	Apply height difference corrections.	4.7 * .84=3.9 HW Height 1.2 * .85 =1.0 LW Height

New York (The Battery), N.Y., 1993

Times and Heights of High and Low Waters

Month	Day	Time (h m)	Height (ft)	Height (cm)
July	8 Th	0507	0.3	9
		1136	4.6	140
		1720	1.0	30
		2340	4.7	143
	9 F	0545	0.6	18
		1218	4.6	140
		1805	1.3	40
	10 Sa	0021	4.5	137
		0626	0.8	24
		1300	4.5	137
		1900	1.4	43
	23 F	0458	−0.3	−9
		1125	5.5	168
		1724	0.3	9
		2341	5.4	165
	24 Sa	0646	−0.1	−3
		1220	5.5	168
		1823	0.5	15
	25 Su	0036	5.1	155
		0642	0.2	6
		1313	5.5	168
		1934	0.7	21
August	8 Su	0528	0.9	27
		1212	4.7	143
		1802	1.4	43
	9 M	0007	4.2	128
		0552	1.1	34
		1250	4.6	140
		1858	1.5	46
	10 Tu	0045	4.1	125
		0629	1.3	40
		1330	4.6	140
		2021	1.6	49
	23 M	0020	5.0	152
		0617	0.3	9
		1252	5.7	174
		1912	0.7	21
	24 Tu	0116	4.7	143
		0725	0.6	18
		1351	5.5	168
		2025	0.8	24
	25 W	0217	4.4	134
		0837	0.8	24
		1451	5.3	162
		2131	0.8	24
September	8 W	0004	4.0	122
		0536	1.2	37
		1241	4.7	143
		1916	1.5	46
	9 Th	0058	3.9	119
		0631	1.4	43
		1333	4.7	143
		2047	1.4	43
	10 F	0159	3.9	119
		0833	1.5	46
		1439	4.8	146
		2148	1.2	37
	23 Th	0201	4.4	134
		0815	1.0	30
		1428	5.1	155
		2106	0.8	24
	24 F	0306	4.3	131
		0924	1.0	30
		1530	5.0	152
		2205	0.7	21
	25 Sa	0409	4.4	134
		1024	0.9	27
		1630	4.9	149
		2255	0.6	18

Time meridian 75° W. 0000 is midnight. 1200 is noon.
Heights are referred to mean lower low water which is the chart datum of soundings.

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Figure 7-4. Excerpt from Tide Table, table 1.

Now that we have the subordinate station data, we can complete the remainder of the problem; finding the height of the tide at the desired time of 0700.

OPNAV 3530/40 (4-73) HT OF TIDE	Step	Action	Completed Strip Form
Duration **Rise** **Fall**	15.	To compute this duration, find the two subordinate stations' times that bracket your desired time. In this case they are 0622 and 1331. Calculate the total time difference between the two (1331 - 0622 = 7 hours 09 minutes). We can tell by observation that between 0622 and 133 1 the tide is rising. Enter this data on the worksheet.	7h 09m rising
Time Fm **Near Tide**	16.	Next, determine the time nearest high/low for which the desired tide height is required. In this case the desired time of 1100 is nearest to high tide at 133 1. Now find the time difference between the two (1331 - 1100 = 2 h 31m). Enter this data on the worksheet.	2h 31m
Range of Tide	17.	Now calculate the range of tide. Simply find the difference between the height of high and low tide from the same two subordinate station times bracketed for duration above (3.9 - 1.0 = 2.9). Enter this data or the worksheet.	2.9
Ht of Near Tide	18.	Enter the height of the nearest tide this case from the high tide at 1331.	3.9 ft

How to Determine the Height of Tide, Continued

OPNAV 3530/40 (4-73) HT OF TIDE	Step	Action	Strip Form
Corr Table III	19.	Enter the upper portion of the table with the nearest duration of rise or fall (upper left margin) for 7h 09m.	
	19 a.	Follow this line horizontally until you reach the column for the nearest value for the time to nearest high/low water (2 hour 3 1 minutes).	
	19 b.	Follow this column down to the lower half of the table until you intersect the nearest value for the range of tide (lower left margin). Extract the data (1.0 ft) and enter on the worksheet.	1.0 ft
HT of Tide	20.	To find the final piece of information you need, height of tide, you must apply the correction as directed by the instructions at the bottom of table Those instructions are as follows: *"When the nearest tide is high water, subtract the correction."* *"When the nearest tide is low water, add the correction."* In this case the nearest tide is high, so you subtract the correction (3.9 -1.0 = 2.9 ft).	2.9 ft

You have now computed the height of tide for 1100 standard time, September 8, 1993, at George Washington Bridge, N.Y. The tide will be 2.9 feet above mean lower low water (charted depth).

How to Graph Tide Data

Introduction

When the height of tide is required for a number of times on a certain day, the graphical method of determining tides can be very useful. For example, a buoy tender may spend an entire day servicing aids to navigation in one particular area. Having the tides displayed on a graph for the entire day will save you from having to calculate the height of tide separately for each aid you visit.

To illustrate how to construct a tide graph, we will use the same data presented in the previous section for the height of tide at Tue Marshes Light, Virginia. The form shown in figure 7-5 should prove helpful in guiding you through the problem, however, regular graph paper can be used if you desire.

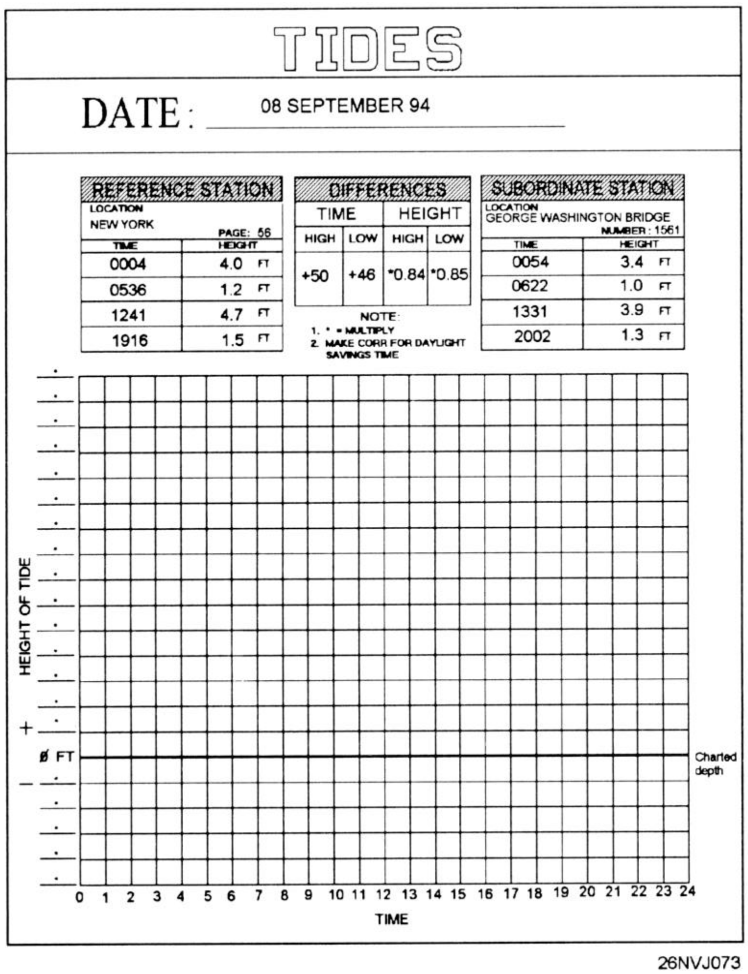

Figure 7-5. Sample tide graph form.

Step	Action
1.	Complete the upper section of the form by filling in the reference, subordinate, and differences data for 8 SEP 93. Notice on the graph that time is listed along the bottom in even hours (interpolate when necessary), and the height is listed along the left margin. The solid line at 0 feet is the base line, or charted depth.
2.	Set the height scale. Each line can represent one foot, one-half foot, one-tenth foot, and so on. Try to use a scale that results in the largest graphical representation practical. In our example, the largest increment we can use and still remain on the graph is 0.2 feet per line.
3.	Plot the high and low tide times and heights on the graph (fig. 7-6). Use the subordinate station data since you wish to know the tides at this location (Tue Marshes Light). Start with the first time and height listed, 0057 at 0.6 feet. Plot as shown below. Continue by plotting the other three points, then connect each point with a light line.

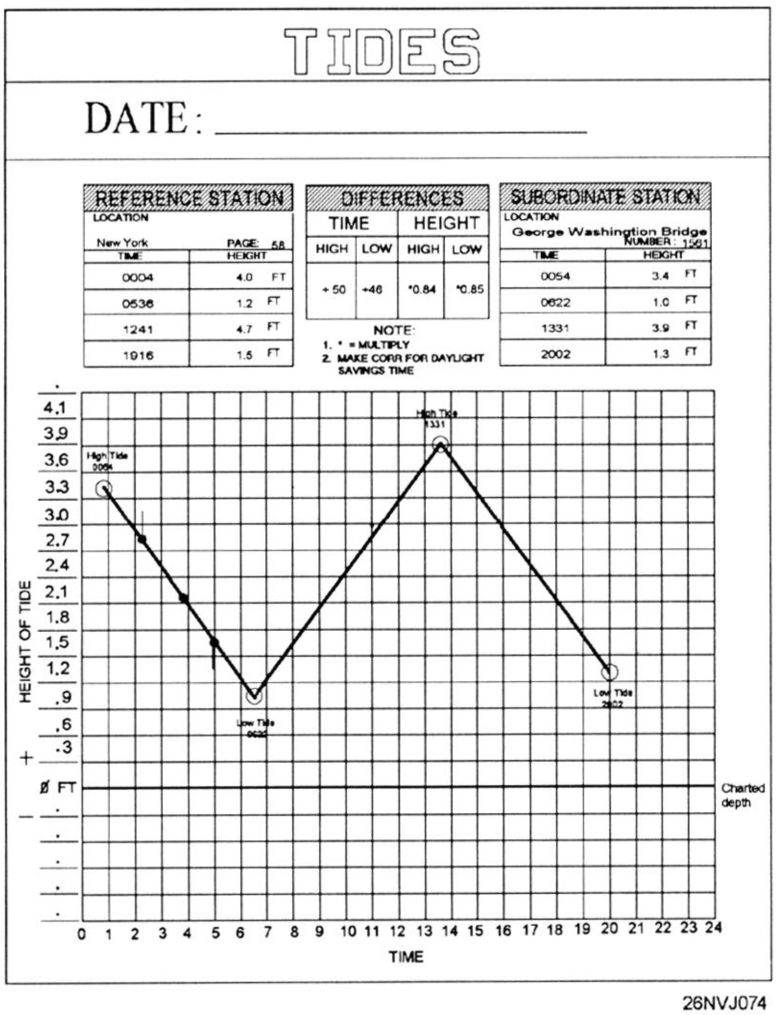

Figure 7-6. Plot the times of high and low water on the graph.

Step	Action
4.	Divide the first line into four equal segments as shown in figure 7-6. The easiest way to do this is to extract the length of the line with dividers and place this length on the height scale. In the case of the first line, this distance is 2.0 feet (approximately). Divide this by 4 and you have the length of each segment 2.0/4 = 0.5 feet. Measure 0.5 feet along the height scale with your dividers, then, starting at either end, divide the line into four segments.
5.	At the quarter point next to the high water point, draw a vertical line above the point; and at the quarter point next to low water point, draw a vertical line below the point equal to a distance of 1/10th of the total length of this line segment (i.e., 2.0 x .l = 0.2 feet). Refer to the example
6.	Repeat steps 4 and 5 for the remaining two lines as shown in figure 7-7. Be sure to use the length of the line you are working with for your computations; using the same measurement for the first line will not work.

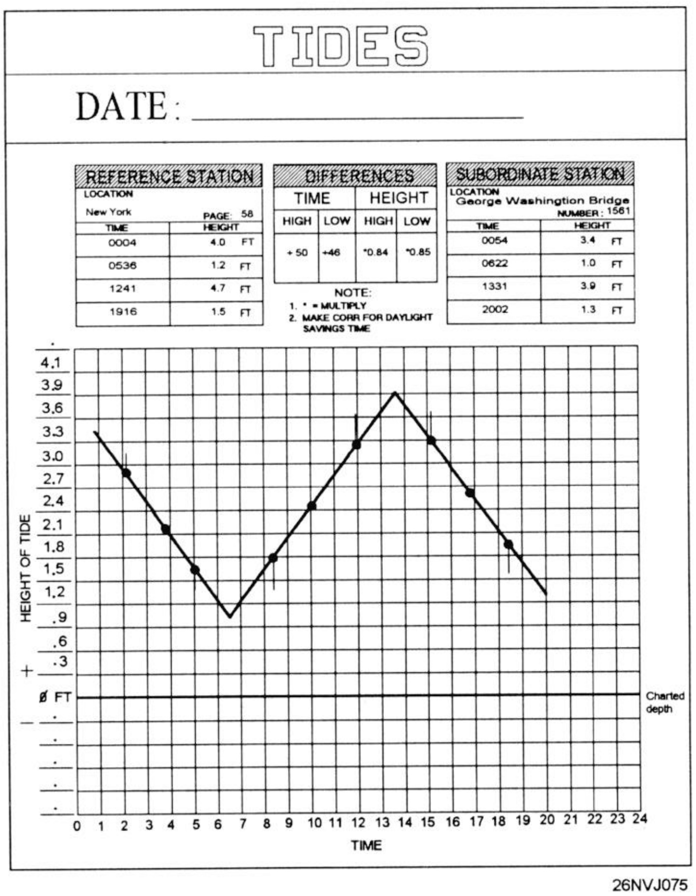

Figure 7-7. Repeat steps for the remaining two lines.

Step	Action
7.	Draw a smooth curve through the points of high and low waters and the intermediate points, making the curve well rounded near the high and low waters as shown in figure 7-8. A french curve is helpful although freehand is fine.

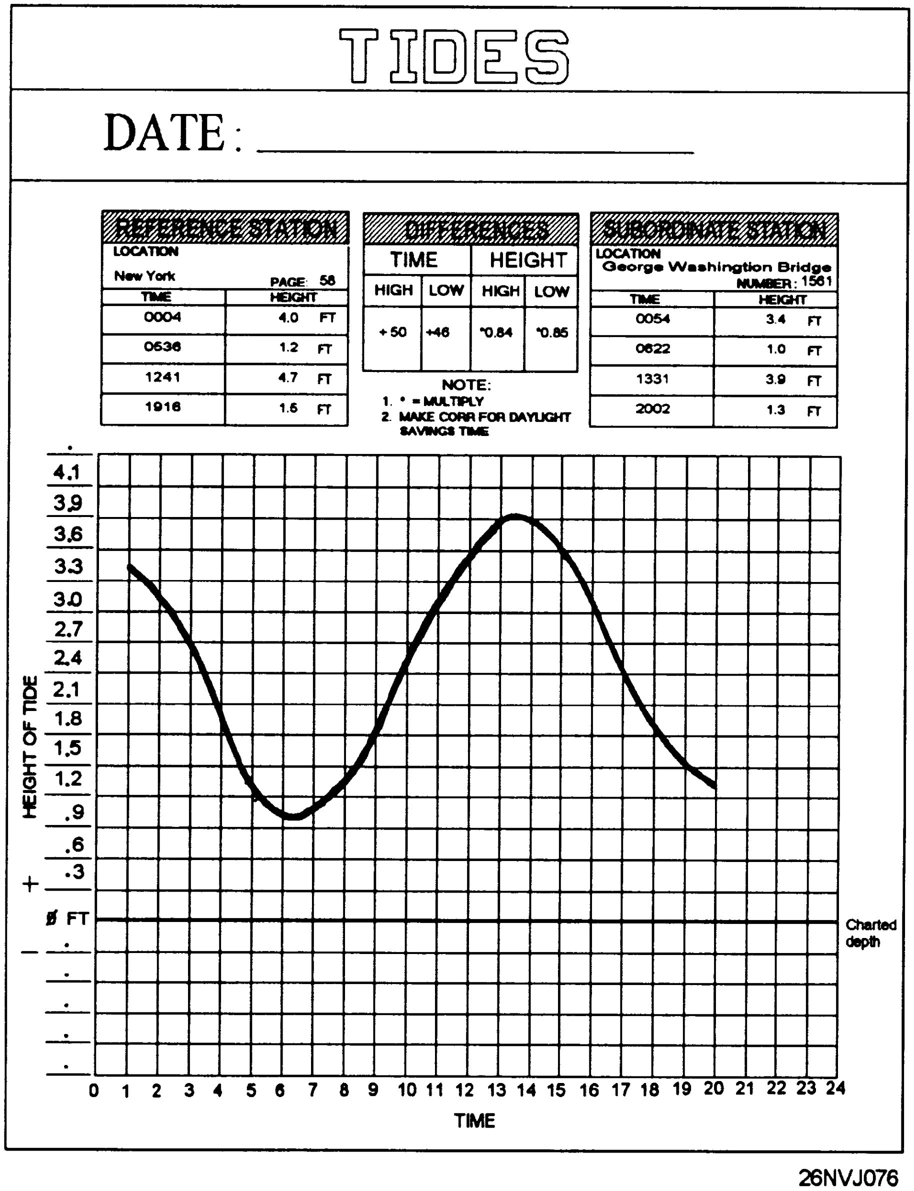

Figure 7-8. Draw a smooth curve through the points.

Tidal Currents

Introduction

In navigation, the effect of the tidal current is often of more importance than the changing depth due to the tide; in fact, many mariners speak of "the tide" when they actually have the flow of the tidal current in mind. **Currents** can be defined as the horizontal movement of water, and may be classified as either tidal or nontidal.

Tidal Currents. These currents are caused by gravitational interactions between the Sun, Moon, and Earth just like the vertical rise and fall called tide, which we have discussed. Study the terms associated with tidal currents.

Term	Definition
Flood Current	When the horizontal movement of water is toward shore or up a tidal river or estuary, the current is said to be flooding.
Ebb Current	When the horizontal movement of water is away from shore or down a tidal river or estuary, the current is said to be ebbing.
Slack Water	The period of time where there is little or no current is called the minimum before flood or ebb.
Duration of Flood	The interval of time in which a tidal current is flooding.
Duration of Ebb	The interval in which the current is ebbing. In a normal semidiurnal tidal current, the duration of flood and duration of ebb will each be approximately 6 hours, but can vary.
Set	The direction of the current is called SET, and is expressed in the direction ***TOWARD*** which the current flows.
Speed of Current or Drift	The velocity of the current is called **speed of current** and is sometimes referred to as **drift.**

Nontidal Currents. There are known and charted currents in all three of the major oceans that are classified as major currents. In the Pacific, the more important ones to note are the North Equatorial, South Equatorial, Equatorial Counter, Japan Stream, Oyashiwo, Californian, Australian, and Peruvian. In the Atlantic Ocean, the Gulf Stream is the most notable because of its clear definition as an ocean current and its effect on shipping and weather. Another type of tidal current you might encounter is called a **ROTARY** current. A rotary current is basically one that flows continually with the direction of flow changing through all points of the compass during the tidal period. Rotary currents are usually found offshore where the direction of flow is not restricted by any barriers.

The Basics

Tidal currents are most pronounced in the entrances to large tidal basins that have restricted openings to the sea. Helmsmen should keep this fact in mind because they often experience difficulty in steering ships in tidal basins. Tide rips caused by swift tidal currents flowing over an irregular bottom often set up rips and eddies that are nearly always deceptive in appearance and will sometimes change a ship's course as much as 30°. One characteristic of a tide rip is in the coloring of the water. The line it caused may not always be straight, but it can usually be seen. You may also observe small wavelets caused by the wind. The water outside the current will often have many small wavelets, whereas the swift running current may be barren of wavelets; again, a quite visible line may be detected, giving the helmsman a clue to what may lie ahead as the ship passes from one side of the line to the other. Another clue for the helmsman is to observe the current trail streaming from a buoy.

In rivers or straits, or where the direction of flow is more or less restricted to certain channels, the tidal current is reversing; that is, it flows alternately in approximately opposite directions with an instant or short period of slack water at each reversal of the current. During the flow in each direction, the speed varies from zero, or near zero at the time of slack water to a maximum, either flood or ebb, about midway between the slacks.

Tidal Current Tables

Layout

Tidal Current Tables are tables that give daily predictions of the times and speeds of the tidal currents. The tables are issued annually in two volumes: one for the Atlantic Coast of North America and the other for the Pacific Coast of North America. These tables are set up basically the same as the Tide Tables. The Tidal Current Tables consist of five tables plus a number of current diagrams and data concerning wind-driven currents, the gulf stream, the combination of currents, and current diagrams. A brief discussion of the five tables is given below.

Table 1 - Daily Current Predictions. This table gives the predicted times of slack water and the predicted times and speeds of maximum current, both flood and ebb, for each day of the year at a number of reference stations. Also listed at the top of each page is the direction of set toward which the currents flow. Like the Tide Tables, data in this book are listed in standard time, so you must add 1 hour to convert the times to daylight savings time.

Table 2 - Current Differences and **Other Constants and Rotary Currents.** This table lists data for subordinate stations. When this data is applied to the predicted times and speeds at the appropriate reference stations, reasonable approximations of the current at the subordinate station may be computed. Later in this assignment, we will use tables 1 and 2 to calculate the speed of current at a subordinate station.

Table 3 - Speed of Current at Any Time. This table allows you to calculate the current at any time, not just the time of slack and maximum current. We will work an example problem later in this assignment.

Table 4 - Duration of Slack. This table provides a means of calculating the approximate period of time during which weak currents not exceeding 0.1 to 0.5 knots will be encountered. This duration includes the last of the flood or ebb and the beginning of the following ebb or flood, or half the duration will be before and half after the time of slack water. Buoy tender sailors may find this table helpful if an aid to navigation can only be worked safely at slack water.

Table 5 - This table lists data for a number of offshore stations for the direction and average speed of the rotary tidal current for each hour of the tidal cycle.

Current Calculations

Example of Current Problems

In the following example, we will calculate the times of the minimum currents and the times and speed of the maximum currents on the morning of 8 September 1993 at a location known as **Sewells Point.** All of the figures in these examples are excerpts from the Tidal Current Tables.

OPNAV 3530/40 (4-73) HT OF TIDE	Step	Action	Completed Strip Form
Date	1.	Enter the desired date.	08 SEP 93
Location	2.	Enter the location. Look up Sewells Point alphabetically in the **index to stations.** The **index to stations** is located in the back of the Tidal Current Tables. Find the index number (#5121) for Sewells Point, note this number because you will use it in step 4.	Sewells Point
Time	3.	Enter the desired time.	1100
Ref Station	4.	The **reference station** is found by first finding our local or subordinate station (Sewells Point) #5121, in table 2, and then look in the center of the DIFFERENCE column and follow it upward to the line entitled "on Chesapeake Bay Entrance p. 44."	Chesapeake Bay Entrance p. 44

Chesapeake Bay Entrance, Virginia, 1993

F–Flood, Dir. 300° True   E–Ebb, Dir. 129° True

July

Day	Slack	Maximum		Day	Slack	Maximum	
7 W	0117	0443	1.2E	22 Th	0058	0419	1.6E
	0806	1019	0.6F		0733	1001	1.0F
	1312	1646	1.1E		1310	1835	1.5E
	2000	2237	0.9F		1941	2217	1.2F
8 Th	0151	0524	1.2E	23 F	0139	0511	1.6E
	0850	1106	0.6F		0822	1053	1.1F
	1400	1736	1.0E		1409	1736	1.4E
	2046	2323	0.8F		2039	2311	1.1F
9 F	0222	0603	1.1E	24 Sa	0223	0606	1.5E
	0935	1158	0.6F		0913	1150	1.1F
	1451	1829	0.9E		1512	1840	1.4E
	2139				2141		

August

Day	Slack	Maximum		Day	Slack	Maximum	
7 Sa	0143	0511	1.1E	22 Su	0200	0539	1.6E
	0848	1116	0.6F		0844	1124	1.2F
	1417	1748	0.9E		1451	1822	1.5E
	2107	2336	0.6F		2128	2351	0.9F
8 Su	0214	0553	1.1E	23 M	0252	0638	1.5E
	0929	1201	0.6F		0942	1222	1.1F
	1506	1837	0.8E		1557	1925	1.3E
	2157				2233		
9 M		0021	0.5F	24 Tu		0050	0.7F
	0246	0836	1.1E		0351	0738	1.3E
	1011	1246	0.6F		1048	1323	0.9F
	1604	1824	0.7E	◐	1708	2031	1.2E
	2252				2342		

September

Day	Slack	Maximum		Day	Slack	Maximum	
7 Tu	0211	0559	1.0E	22 W		0032	0.7F
	0924	1200	0.6F		0334	0719	1.3E
	1514	1851	0.8E		1025	1300	0.9F
	2217			◐	1640	2009	1.2E
					2322		
8 W		0031	0.4F	23 Th		0134	0.6F
	0246	0649	1.0E		0445	0824	1.2E
	1012	1246	0.6F		1137	1409	0.7F
	1617	1942	0.7E		1751	2119	1.1E
	2315						
9 Th		0118	0.3F	24 F	0031	0249	0.5F
	0332	0739	1.0E		0553	0936	1.1E
	1108	1337	0.6F		1247	1544	0.7F
○	1723	2038	0.8E		1856	2226	1.1E

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Figure 7-9. Excerpt from Tidal Current Tables.

OPNAV 3530/41 (4-73) VEL OF CURRENT	Step	Action	Completed Strip Form
Time Diff Slack Water	5.	Inspect reference station time data. Determine whether the desired time falls between flood or ebb times. In our case the current is flooding. We need to know this to determine which slack water time difference to use. Table 2 labels slack water as Min. before Flood or Min. before Ebb. Enter the time difference.	- 0 41
Time Diff Max Current	6.	Enter the flood time difference.	- 0 47
Vel Ratio Max Flood	7.	Follow the data to the right and find the values for velocity ratios and directions from the SPEED RATIOS and AVERAGE SPEED AND DIRECTIONS columns.	1.1
Vel Ratio Max Ebb	8.	Enter ratio.	1.0
Flood Dir	9.	Enter direction.	195°
Ebb Dir	10.	Enter direction.	000°

No.	PLACE	Meter Depth	POSITION Latitude	POSITION Longitude	TIME DIFFERENCES Min. before Flood	TIME DIFFERENCES Flood	TIME DIFFERENCES Min. before Ebb	TIME DIFFERENCES Ebb
		ft	North	West	h m	h m	h m	h m
	HAMPTON ROADS–cont. Time meridian, 75° W				on Chesapeake Bay Entrance, p.44			
5116	Willoughby Bay entrance		36° 57.7'	76° 17.9'	−2 12	−1 55	−2 21	−2 19
5121	Sewells Point, channel west of		36° 57.5'	76° 20.4'	−0 41	−0 47	−1 23	−1 11
5126	Norfolk Harbor Reach (Buoy R "8")	13d	36° 57.00'	76° 20.37'	−0 18	−0 42	−1 36	−0 16
	... do.	42d	36° 57.00'	76° 20.37'	−0 33	−1 00	−0 22	+1 04
5131	Sewells Point, pierhead	7	36° 56.8'	76° 20.1'	−0 52	−0 40	−1 01	−1 04
	Newport News							
5136	Channel, middle	15	36° 57.3'	76° 22.9'	−0 43	−0 23	−0 12	−1 01
5141	Channel, west end	15	36° 57.20'	76° 24.80'	−0 16	−0 20	+0 03	−0 09
5146	Middle Ground, 1 mile south of	7	36° 56.0'	76° 23.2'	+0 33	+0 50	+0 24	+0 26

SPEED RATIOS Flood	SPEED RATIOS Ebb	Minimum before Flood knots	Minimum before Flood Dir.	Maximum Flood knots	Maximum Flood Dir.	Minimum before Ebb knots	Minimum before Ebb Dir.	Maximum Ebb knots	Maximum Ebb Dir.
0.4	0.3	--	--	0.3	135°	--	--	0.4	330°
1.1	1.0	--	--	0.9	195°	--	--	1.2	000°
0.8	0.7	--	--	0.6	183°	0.1	094°	0.9	011°
0.6	0.3	--	--	0.5	152°	--	--	0.3	000°
0.7	0.6	--	--	0.6	195°	--	--	0.8	010°
1.3	0.8	--	--	1.1	244°	--	--	1.1	076°
0.8	0.5	--	--	0.7	280°	0.1	010°	0.6	092°
1.4	1.0	--	--	1.1	270°	--	--	1.2	100°

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Figure 7-10. Excerpt from Tidal Current Table.

OPNAV 3530/41 (4-73) VEL OF CURRENT	Step	Action	Completed Strip Form
Ref Sta Slack Water Time	11.	Enter the reference station slack water time.	1012
Time diff	12.	Enter the time difference for slack water from step 5.	- 0 41
Local Sta Slack Water Time	13.	Apply the time correction.	0931
Ref Sta Max Current Time	14.	Enter the reference station maximum current time.	1246
Time Diff	15.	Enter the time difference for slack water from step 5.	-0 47
Local Sta Max Current Time	16.	Apply the time correction.	1159
Ref Sta Max Current Vel	17.	Enter the maximum current velocity.	.6 F
Vel Ratio	18.	Enter the velocity ratio for flood from step 7.	1.1
Local Sta Max Current Vel	19.	Multiply the values from steps 17 and 18 to find the maximum current velocity at Sewells Point.	.66 kt F
Int Between Slack and Desired Time	20.	Find the difference between the time of slack water and our desired time of 1100.	1 h 29 m
Int Between Slack and Max Current	21.	Find the difference between the time of slack water and maximum current.	2h 28m
Max Current	22.	Enter the value from step 19.	66
Factor Table 3	23.	Enter factor table 3 with the values from steps 2 1 and 21. Note the table value.	.8
Velocity	24.	Multiply the value from steps 22 and 23. Round to the closest tenth of a knot.	528 rounded to .5 kt
Direction	25.	Enter the direction of the flood current from step 9.	195°

How to Graph Tidal Currents

Procedure

The graphing of current velocity information is generally the same as graphing tide data. The most important difference is that tide height changes at a fairly constant rate. Current velocity on the other hand is related to many factors; for complete information on current velocity, refer to *Duttons,* chapter 10.

We can use the times between slack water and maximum current to plot our data. Table 4 can help us determine the amount of time a current is weak and it should also help us make an educated guess of how steep a curve must be plotted.

You may want to overlay the current data on the same graph as the one that has tide data for the same period. If this is the case, it is normally acceptable to omit drawing curves for the current data. Instead, you would draw straight lines between slack water and maximum current. At the intersection of each line, annotate SW for slack water and MC for maximum current respectively. If you do choose to overlay, make sure you use different colors of ink, one that represents tide data and one that represents current data.

What's Next

In our next chapter you'll learn how the Quartermaster keeps track of the ship's position.